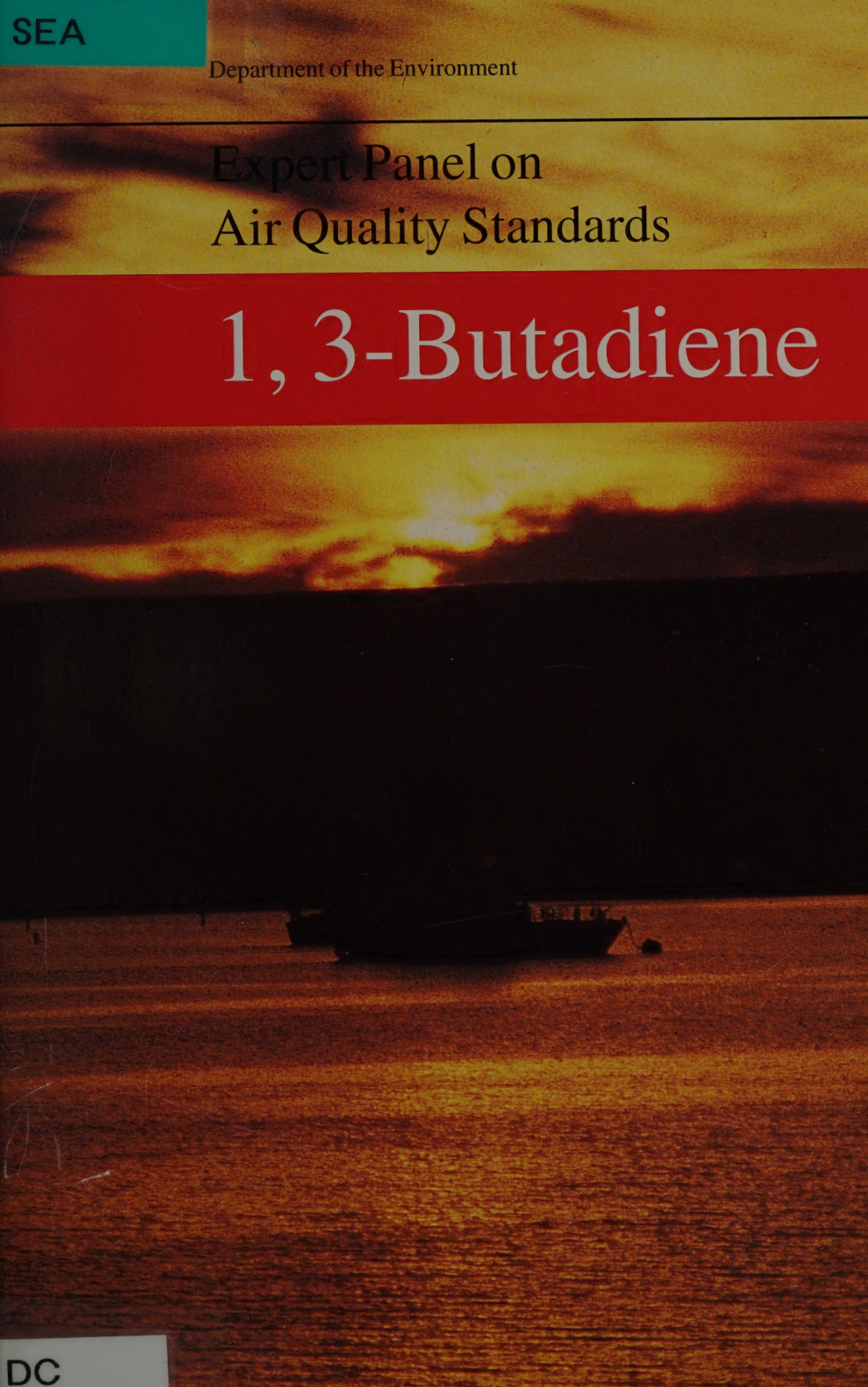
Department of the Environment

Expert Panel on Air Quality Standards

1, 3-Butadiene



Department of the Environment

Expert Panel on Air Quality Standards

1,3-Butadiene

London: HMSO

First published 1994

ISBN 0 11 753034 4

Previous Reports by the Expert Panel on Air Quality Standards

1st report	Benzene	February 1994	ISBN 011 752859 5
2nd report	Ozone	May 1994	ISBN 011 752873 0

The cover photograph is reproduced by
kind permission of Professor Anthony Seaton.

Contents

Page

v–vi Terms of Reference and Membership of the Panel

vii Acknowledgements

1 **Introduction**

3 **Sources of Exposure to 1,3-Butadiene**

5 **Measurement and Monitoring of 1,3-Butadiene**

9 **The Effects of 1,3-Butadiene on Human Health**

17 **Justification of an Air Quality Standard for 1,3-Butadiene**

19 **Recommendation for an Air Quality Standard for 1,3-Butadiene**

21–22 Figures 1-2

23 Bibliography

A Recommendation for a United Kingdom Air Quality Standard for 1,3-Butadiene

Expert Panel on Air Quality Standards

The Expert Panel on Air Quality Standards (EPAQS) was set up by the Secretary of State for the Environment in 1991 following the undertaking, in the Environment White Paper 'This Common Inheritance' published in September 1990, to establish an expert panel to advise the Government on air quality standards. The terms of reference of the Panel are:

'To advise, as required, on the establishment and application of air quality standards in the United Kingdom, for purposes of developing policy on air pollution control and increasing public knowledge and understanding of air quality, taking account of the best available evidence of the effects of air pollution on human health and the wider environment, and of the progressive development of the air quality monitoring network.'

This report is one in a series which will deal with pollutants suggested to the Panel by the Department of the Environment. Reports will be made on individual pollutants except where the Panel decide to deal with more than one because of the relationship between pollutants.

MEMBERSHIP OF THE PANEL

Chairman

Professor A Seaton MD, FRCP, FRCPE, FFOM
University of Aberdeen Medical School

Members

Dr R Agius MD, FRCPE, FFOM
Faculty of Medicine, University of Edinburgh

Dr P J Baxter MD, MSc, FRCP, FFOM
University of Cambridge

Professor P G J Burney MA, MD, FFPHM
United Medical and Dental Schools of Guy's and St Thomas's Hospitals, London

Dr R L Carter MA, DM, DSc, FRCPath
Royal Marsden Hospital, Sutton, Surrey

Mr J W Cherrie BSc, FIOH
University of Aberdeen and Institute of Occupational Medicine, Edinburgh

Dr R G Derwent MA, PhD
Meteorological Office

Professor R M Harrison PhD, DSc, FRSC, FRMetS, FRSH
University of Birmingham

Professor S T Holgate MD, DSc, FRCP
Faculty of Medicine, Southampton General Hospital

Mr R E Waller BSc
Consultant, London

Observers

Dr P Harrison PhD, CBiol, MIBiol
Department of the Environment

Dr M Topping PhD
Health and Safety Executive

Dr A Wadge PhD, CBiol, MIBiol
Department of Health

Secretariat

Dr M L Williams PhD
Department of the Environment

Dr S M Coster PhD
Department of the Environment

Dr R L Maynard BSc, MB, BCh, MRCPath, FIBiol
Department of Health

Mrs K M Cameron MSc (to 1993). Dr J B Greig MA, DPhil (from 1993)
Department of Health

Ms C J Hartley BSc, PGDipLIS
Department of Health

ACKNOWLEDGEMENTS

We would like to thank the following individuals and organisations for their help.

Dr D N M Coggon
Medical Research Council Environmental Epidemiology Unit
Southampton

AEA Technology
Harwell
Didcot
Oxfordshire

Warren Spring Laboratory*
Stevenage
Hertfordshire

*Warren Spring Laboratory now forms part of AEA Technology, National Environmental Technology Centre, Culham, Abingdon, Oxfordshire OX14 3DB.

Introduction

1. 1,3-Butadiene is a chemical compound, the molecule of which comprises four carbon and six hydrogen atoms. At normal ambient temperatures it is a gas, and trace amounts can be found in the atmosphere that we breathe. These derive mainly from the combustion of petroleum in motor vehicle engines and from other sources of combustion such as fossil fuels and accidental fires.

2. 1,3-Butadiene is used in industry, mainly in the production of synthetic rubber for tyres. It is also present in a number of commercial liquid petroleum gases. It is thus a chemical to which workers have been exposed, and there is evidence that such groups of workers have had a slightly higher than expected risk of cancers of the lymphoid system and bone marrow, lymphomas and leukaemias. Laboratory studies have shown that 1,3-butadiene causes a variety of cancers in rodents and damages the genetic structures of the cell. It is thus a genotoxic carcinogen and, in theory, it is not possible to determine an absolutely safe level for human exposure.

3. In practice, however, it is clear from studies of groups of workers, many of whom have had substantial exposure to 1,3-butadiene, that risks to the general population from the levels currently found in the atmosphere in the United Kingdom must be exceedingly small. We nevertheless recommend that steps should be taken to keep levels as low as is practicable. In this document we summarise briefly the main sources, methods of measurement and evidence of health risks of 1,3-butadiene. We then recommend an Air Quality Standard for the United Kingdom, based on the best evidence available.

Sources of Exposure to 1,3-Butadiene

4. The 1,3-butadiene in the air derives solely from human activity. It is an important industrial chemical, being used particularly in the manufacture of synthetic rubber for tyres. Some commercial liquid petroleum gases also contain up to 8 percent by volume. However, apart from accidental releases from such industrial activities, the 1,3-butadiene in the ambient air comes from combustion. It is mainly derived from combustion of petrol and diesel fuel, but some also comes from house fires and the burning of other fossil fuels. 1,3-Butadiene is also present in cigarette smoke.

5. There is little or no preformed 1,3-butadiene in diesel or in petrol, either leaded or unleaded; the emissions in the exhaust gases being produced by the combustion process itself. The chemicals in petrol from which the 1,3-butadiene is derived, higher olefins, have been present in increasing proportion in petrol over the last decade, and it is likely that the amounts of 1,3-butadiene released into the atmosphere have therefore been rising. However, 1,3-butadiene is removed efficiently by catalytic converters on motor cars and this is likely to reverse any such trend, while increasing use of diesel as a vehicle fuel would be expected partly to counter this.

Measurement and Monitoring of 1,3-Butadiene

6. In contrast to the better known pollutant gases, there is relatively little information on levels of 1,3-butadiene in the ambient air of the United Kingdom. The first measurements were made only in 1990, on the Norfolk coast and in Cumbria, and between mid 1991 and mid 1992 continuous hourly measurements were made at a roadside site in central London. The Department of the Environment is now establishing a network of 12 automatic gas chromatography sites around the country where continuous monitoring of 1,3-butadiene (measuring to an accuracy of $\pm$ 10% and a precision of 0.1 ppb[1]) and other hydrocarbon compounds will take place. Sites have been established in Middlesbrough, London Eltham, London Bloomsbury, Belfast, Edinburgh, Birmingham, Bristol, Cardiff and a site in Leeds is expected to be operational shortly. Thus daily dissemination of information to the public on 1,3-butadiene levels through the Department of the Environment's Air Quality Bulletin is now possible.

7. *Table 1* summarises the available monitoring data for 1,3-butadiene in the United Kingdom since monitoring began in 1990. The measurements have shown a very close correlation between 1,3-butadiene and other pollutants, such as carbon monoxide, oxides of nitrogen and benzene. These relationships are illustrated in *Figures 1* and *2*. The average annual levels to which the population of the United Kingdom is exposed clearly depend on proximity to motor traffic (see *Table 1*). Thus someone living close to a busy road may be exposed to an annual average concentration of about 0.7 ppb, whereas someone living on the Norfolk coast may be exposed to around 0.04 ppb. The very striking difference between urban and rural sites reflects not only differences in traffic density but also the fact that 1,3-butadiene is removed from the atmosphere in a matter of hours by chemical reactions. These prevent it being dispersed far from its source. On the basis of the data in *Table 1* and analysis of the relative concentrations of a number of motor vehicle-derived pollutants measured simultaneously at Cromwell Road and Exhibition Road in London, it is unlikely that annual average 1,3-butadiene concentrations will exceed 1 ppb close to the most heavily trafficked roads in the United Kingdom.

[1] 1 part per billion (ppb) is one part, by volume, in one thousand million, or 1 in 10^9; 1 ppb of 1,3-butadiene is equivalent to 2.21 $\mu g/m^3$ at 25 °C and 1013 millibars.

Table 1 Ambient concentrations of 1,3–butadiene in the United Kingdom

Site	Location	Average concentration (ppb)**	Period of measurement
Exhibition Road, London	Urban roadside*	1.09	July 1991–December 1991***
		0.63	January 1992–June 1992
		(0.86	July 1991–June 1992***)
Bloomsbury, London	Urban roadside*	0.32	February 1993–December 1993
Eltham, London	Urban baseline	0.21	August 1992–March 1994
Middlesbrough	Urban baseline	0.35	January 1992–December 1992
		0.45	January 1993–December 1993
Belfast	Urban baseline	0.65	August 1993–March 1994
Birmingham	Urban baseline	0.41	August 1993–March 1994
Cardiff	Urban baseline	0.60	November 1993–March 1994
Edinburgh	Urban baseline	0.24	October 1993–March 1994
West Beckham, Norfolk	Rural	0.04	January 1990–March 1991
Great Dun Fell, Cumbria	Remote rural	0.01	January 1990–March 1991

* Urban roadside locations are away from the immediate influence of traffic, 5 metres from the kerbside with a sampling inlet 3 metres above the pavement.

** All provisional data (*i.e.* not ratified by national quality assurance/quality control procedures).

*** This period includes the December 1991 pollution episode mentioned in the text of the Report.

8. These very low annual average concentrations do, of course, conceal fluctuations caused by combinations of traffic and weather conditions, and short term higher concentrations may occur. For example, during December 1991 heavy motor traffic at a time of very cold still weather produced a pollution episode during which high levels of all exhaust-derived pollutants were measured in central London. During this episode, the hourly average 1,3-butadiene level remained close to 10 ppb (see *Figure 2*). The highest hourly level, of 30 ppb, had been recorded a few days earlier. Sporadic peaks of 1,3-butadiene have been observed at some of the urban baseline sites in *Table 1*. Their origins have yet to be established but they point to there being some potentially significant industrial sources of 1,3-butadiene. Such intermittent sources are unlikely to contribute significantly to annual average concentrations.

9. There is no evidence that petrol contains anything other than trace quantities of 1,3-butadiene, so petrol evaporation is unimportant as an urban source of 1,3-butadiene. Exhaust emissions are the only urban source which has so far been quantified in the United Kingdom. Vehicles equipped with three-way catalytic converters emit negligible quantities of 1,3-butadiene and offer a reduction in emissions over those produced by non-catalyst cars of at least a factor of twenty. Emissions from diesel cars are detectable at about one tenth of those of non-catalyst cars but emissions of 1,3-butadiene are higher from diesel cars than from cars equipped with three-way catalytic converters. The fitting of oxidation catalysts to diesel cars to meet future emission requirements would, however, lead to a reduction of diesel emissions of 1,3-butadiene. It is likely therefore that urban 1,3-butadiene levels will decline dramatically as non-catalyst cars are phased out in the future and that this decline will not be hindered significantly by increased urban traffic growth.

10. The Panel, in deciding upon a recommended Standard, have considered the time period over which 1,3-butadiene measurements should be made. As is discussed in the next section, 1,3-butadiene has the potential to cause leukaemias and lymphomas. At concentrations occurring in the ambient atmosphere, 1,3-butadiene does not have short-term, or acute, effects. The risk of developing cancer is related to the period of exposure and the concentration to which the person is exposed.

11. The Panel therefore consider it appropriate to recommend a Standard based on a running annual average concentration[2], since this is likely to best reflect the integrated exposure of the population. The Standard is set on the basis of possible health effects; it is intended that techniques for its monitoring be consistent with those of the Department of the Environment's Enhanced Urban Network. Such an average will tend to obscure individual high concentrations recorded on a daily basis, although pollution episodes such as that of December 1991 in London will still be apparent.

[2] The hydrocarbon analyser utilised in the Department of the Environment's national network collects and analyses samples once per hour. The running annual average concentration is calculated by averaging all appropriate available hourly values.

12. In discussing the recommendation of an Air Quality Standard, the Panel have had in mind the importance of practical measures to ensure compliance. As stated above, the most important of these relate to traffic exhaust emissions. Whilst the Government has already implemented a number of important measures in this direction, there also remains much that individuals can do. Since traffic levels are predictable and since tomorrow's weather conditions can be forecast increasingly accurately, it is possible to estimate the likely atmospheric concentration of 1,3-butadiene and other pollutants the day before they occur. This means that episodes, such as that in December 1991, may be forecast and the public informed of action that could be taken to reduce such levels, and thus reduce the population's lifetime exposure. For example, by restricting the use of motor vehicles at these times it is possible to contribute to reducing the severity of such episodes.

The Effects of 1,3-Butadiene on Human Health

13. Evidence of the hazard of 1,3-butadiene comes from two main sources: firstly, studies of human populations exposed in the workplace and, secondly, from investigations carried out in laboratory rats, mice and monkeys. The Panel put greatest weight on data derived directly from human studies; however, compared with benzene, fewer human data are available and greater emphasis has had to be placed on results from laboratory investigations. The animal data are consistent in showing 1,3-butadiene to be a potent carcinogen and to act, through another chemical to which it is converted in the body, on the genetic material of cells as a genotoxic carcinogen.

14. The Panel recognise that extrapolation from the results of animal experiments to effects in man is difficult and involves uncertainties. There are also difficulties in extrapolating from studies of workers exposed in the past to the general population of today. The levels to which workers may be exposed are very much higher than those in ambient air; for example, a worker could be exposed intermittently to levels of up to 10,000 ppb (the United Kingdom workplace maximum exposure limit) compared with an hourly average of about 20 ppb during a severe short-term atmospheric pollution episode in a city. There is no feasible study in man which will show a measurable effect on health of the relatively low levels occurring in the general atmosphere.

15. The data on absorption, distribution, metabolism (that is, biological and/or chemical breakdown) and elimination of 1,3-butadiene in humans are limited but some information is available from laboratory studies on animals and it is possible to draw some general conclusions. Inhalation studies have indicated that 1,3-butadiene is absorbed through the lungs and can be detected in all tissues which have been examined. Studies comparing uptake in mice, rats and monkeys have shown uptake to be greatest in mice and least in monkeys. 1,3-Butadiene and the main chemical to which it is converted in the body, an epoxide (1,2-epoxybut-3-ene), are eliminated in exhaled air of mice and rats.

16. The metabolism of 1,3-butadiene has been studied in several animal species, and also in tissues derived from them. Differences exist between species and the formation of the dangerous chemicals to which it is converted (epoxides) is most rapid in mice. Laboratory studies have shown that human tissues can produce epoxide metabolites; however, at low doses, the relative capacity of tissues from different species to metabolise 1,3-butadiene is unknown.

17. Short-term human exposures to very high concentrations (several million ppb) of 1,3-butadiene, including experimentation on volunteers conducted in the 1940s before its carcinogenic potential was suspected, have caused irritation of the eyes, nose, throat and skin. Investigations of workers in Eastern Europe exposed occupationally to high concentrations of 1,3-butadiene have shown them to have been at risk of a variety of disorders, including diseases of the blood and nervous system. These studies did not take account of other possible harmful factors. The general public in the United Kingdom would be exposed to much lower concentrations, although for longer periods.

18. The effect of long-term exposure which is of most concern is the induction of cancers of the lymphoid system and blood-forming tissues, lymphomas and leukaemias. An increase in the risks of developing these types of cancers has been reported in groups of workers in the United States from the 1,3-butadiene manufacturing industry and from the styrene-butadiene rubber manufacturing industry. Exposures of rats and mice to high inhaled concentrations of 1,3-butadiene for all or most of their lifetimes have shown similar effects, as well as an increased mortality from other types of malignant disease. Species differences in susceptibility to the development of malignant disease have been demonstrated; mice, particularly females, are sensitive to the carcinogenic effects of 1,3-butadiene with an increase in tumours being noted after long duration exposure to levels of, and in excess of, 6,250 ppb. This increased susceptibility may, in part, be due to the differences in uptake and metabolism of 1,3-butadiene in mice as compared with other animals which were noted previously.

19. Various laboratory studies examining the mode of action of 1,3-butadiene and some of its metabolites have been carried out. 1,3-Butadiene damages the genetic material of cells in various ways and these genotoxic effects indicate that it may cause malignant disease after very small exposures. The Panel have taken the view, as with benzene, that while this could be strictly interpreted as meaning that there is no safe level to which people can be exposed, a more realistic view is that the risks become progressively smaller as the cumulative exposure of an individual is reduced and that there is a level at which increased risks attributable to 1,3-butadiene are exceedingly small and unlikely to be detectable by any practicable method.

20. Further problems in extrapolating risk from groups of industrial workers to the general population relate to the size and make-up of the industrial group studied. In the work reported in the medical literature, the industrial groups (often called 'cohorts', that is defined groups of workers followed forward over time in order to estimate their risks of death from various diseases) have ranged in size from about 2,500 – 12,000. Lymphomas and leukaemias are relatively uncommon in the general population of the United Kingdom, occurring in about 1 person in 2,800, and it is often difficult (on present knowledge) to exclude the possibility that small excesses of cases are chance occurrences. Thus, the smaller the cohort, the greater the disease-causing effect has to be in order for it to be detected. However, in one of the cohorts the exposure histories of workers who had died of lymphoma or leukaemia were compared with those of control workers without these diseases, matched for factors such as age, year of employment and factory. The results showed those who had died of lymphoma or leukaemia to have had a substantially greater occupational exposure to 1,3-butadiene than had the control workers.

21. An important point the Panel have considered in recommending a Standard concerns the differences between past industrial cohorts and the general population. The former generally comprised fit males, young and middle-aged, whereas the general population also includes children, pregnant women, the elderly and the sick, some of whom may be particularly sensitive to toxic chemicals. Industrial workers are potentially exposed to relatively high concentrations for perhaps 8 hours per day, five days weekly for 40 years, whereas the general population is exposed to much lower concentrations, but throughout their lifetimes.

22. The Panel have examined published reports of studies of lymphomas and leukaemias in groups of workers exposed to 1,3-butadiene. None of these provided information on measured exposures of workers who had died from these cancers; however, attempts have been made to categorise workers' exposure using job description data (see *Table 2*). Exposure data for people currently exposed to 1,3-butadiene and doing jobs having the same job description as those identified as being at particular risk from 1,3-butadiene were also available (see *Table 3*). Current exposures in these jobs are likely to be lower than in the past owing to changes in work practices and improved controls. For example, the American Conference of Governmental Industrial Hygienists' threshold limit value[3] for exposure to 1,3-butadiene over an 8-hour working day in a 40-hour working week was, until 1984, 1,000,000 ppb (as a time-weighted average), as compared with the present value of 10,000 ppb and a proposal that it should be further reduced to 2,000 ppb. Assuming that the job description applied to the same type of work being done now as formerly and given that current workplace levels are lower than in the past,

[3] The threshold limit value is the concentration to which it is believed that nearly all workers may be repeatedly exposed under the defined conditions without adverse health effects. It is not intended for use outside the industrial workplace.

thus providing an inbuilt safety factor, the Panel used the current exposure data to obtain a level of exposure for the groups of workers identified as probably not having been at increased risk of developing these cancers. Consideration of these data led the Panel to conclude that it was unlikely that an excess risk of lymphomas or leukaemias would be detectable at exposures below about 1,000 ppb. We note, however, the relative weakness of the available information on human exposures, even compared with that available for benzene, and therefore acknowledge the uncertainty surrounding this figure.

Table 2 Summary of recent 1,3-butadiene epidemiological studies

Authors	Study	Number of subjects	Cancer type*	Number of deaths	SMR**	95% CI‡
Downs, Crane & Kim 1987 updated by Divine 1990	1,3-Butadiene production plant, Port Neches, Texas process workers 1943–1979 (cohort study)	2582	Lymphatic and haematopoietic	25	130	84-192 (104-435)
			(Lymphosarcoma and reticulosarcoma)	(9)	(229)	
Meinhardt *et al.* 1982	Styrene-butadiene rubber facility, Port Neches, Texas, production workers, Plant A, 1943–1976 (cohort study)	1662	Lymphatic and haematopoietic (leukaemia, aleukaemia)	9 (5)	155 (203)	71-295 (66-472)
		All deaths occurred in men first employed between 1943 and 1945 after which the process changed from batch to continous feed operation.				
Meinhardt *et al.* 1982	Styrene-butadiene rubber facility, Port Neches, Texas, production workers, Plant B, 1950–1976 (cohort study)	1094	Lymphatic and haematopoietic (leukaemia, aleukaemia)	2 (1)	78 (101)	10-283 (3-563)
Matanoski, Santos-Burgoa & Schwartz 1990	Styrene-butadiene rubber facilities, United States and Canada, 1943–1982 (cohort study)					
	production workers:	3124	All lymphopoietic (other lymphatic)	19 (9)	146 (260)	88-227 (119-494)
	maintenance workers:	**3271**		**14 (2)**	**75 (39)**	**41-126 (5-141)**
	utility workers:	457		5 (2)	203 (313)	66-474 (62-695)
	others:	2867		12 (2)	87 (54)	45-152 (7-196)

Table 2 (continued) Summary of recent 1,3-butadiene epidemiological studies

Cowles *et al.* 1994	1,3-Butadiene production plant, Deer Park Manufacturing Complex, interrupted production; production workers, 1948–1989 (cohort study)	614	Lymphatic and haematopoietic	0	–	–

Authors	**Study**	**Number of subjects**	**Cancer type**	**Number of deaths**	**OR†**	**95% CI‡**
Santos-Burgoa *et al.* 1992	Styrene-butadiene rubber facilities, United States and Canada, 1943–1982 (nested case-referent study)	59 cases matched with 193 controls	All lymphohaematopoietic (leukaemia)	59 (26)	2.12 (7.39)	0.86–5.18 (1.32–41.3)

* Despite the diversity of terms listed here all of them refer to different categories of lymphomas and/or leukaemias. The descriptions and figures in parentheses represent sub-groups of the main category.

** SMR: Standardised Mortality Ratio, the ratio of the observed number of deaths in the occupationally exposed cohort to the expected number of deaths in a control group of this size of unexposed persons multiplied by 100. For control groups the studies have used either the national populations or workers in other industries.

† OR: Odds Ratio, the odds in favour of exposure amongst cases to the odds in favour of exposure amongst controls. Values above 1.0 indicate a greater risk of exposure to 1,3-butadiene in the cases.

‡ CI: Confidence Interval, the 95% CI is the range in which, allowing for variability in study populations, there is a 95% chance of the true result falling. If, in the Table, the value 100 is not included in the 95% CI shown for the SMR then there is only a 1 in 40 chance that the increase in leukaemia/lymphoma deaths is an erroneous result ($p < 0.025$). Similarly, if the value 1.0 is not included in the 95% CI shown for the OR then there is only a 1 in 40 chance that the greater exposure of the cases is an erroneous result.

Table 3 Exposure profiles (1990) of U.S. workers in 1,3-butadiene production identified in the epidemiological studies as not being at increased risk of developing lymphomas or leukaemias*

Industry	Worker category	Percentage exposed to:		
		< 1000 ppb	**< 2000 ppb**	**< 5000 ppb**
Crude 1,3-butadiene production	Maintenance	85%	91%	96%
1,3-Butadiene monomer production	Maintenance	85%	91%	96%
1,3-Butadiene polymer + other	Maintenance	85%	91%	96%
	Utilities	93%	96%	100%

*Compiled from Department of Labor, Occupational Safety and Health Administration, 1990.

Justification of an Air Quality Standard for 1,3-Butadiene

23. The Panel accept that 1,3-butadiene is a genotoxic carcinogen and that therefore no absolutely safe exposure level can be defined. Nevertheless, for practical purposes we believe that a concentration may be proposed at which the risks are exceedingly small and unlikely to be detectable by any practicable method. We have taken the view, therefore, that an Air Quality Standard can be set. In recommending a Standard, we have considered evidence concerning the risks of lymphomas and leukaemias in cohorts of workers exposed to 1,3-butadiene, since there are no useful data available on the effects on humans or animals of the very low concentrations found in the ambient air. Considerable uncertainties surround the estimates of exposure in such cohorts, making the accurate extrapolation of risk from high occupational to low ambient exposure impossible and which give to such formal quantitative risk assessments a misleading appearance of precision. This general view has also been taken by the Department of Health's Committee on Carcinogenicity.

24. Consideration of the evidence has led the Panel to conclude that it is unlikely that increased risks of lymphomas and leukaemias would be detectable by any practicable means in cohorts of workers exposed to 1,000 ppb of 1,3-butadiene over a working lifetime. In order to take account of the difference between working lifetime (approximately 77,000 hours) and chronological life (about 660,000 hours), the figure of 1,000 ppb has been divided by 10. Further, since it is reasonable to suppose that the population includes people, such as those exposed to other causes of lymphomas and leukaemias, and individuals who might be particularly sensitive to 1,3-butadiene, the Panel have recommended that a further safety factor be applied. In the absence of any evidence on interindividual differences we have chosen a factor of 10, analogous to factors used for this purpose in regulatory toxicology for non-carcinogens. We thus arrive at a value of 10 ppb.

25. The Panel noted the weaknesses of the exposure data in epidemiological studies of persons exposed in industry. We therefore reviewed the studies in animals on the carcinogenicity of 1,3-butadiene. It is clear that the recent laboratory data provide good evidence that 1,3-butadiene is a genotoxic carcinogen. Further, the biochemical pathways by which it is activated also exist in humans. The Panel were unanimous in agreeing that the levels of genotoxic carcinogens in the environment should not be allowed to rise.

We also noted that the concentrations of 1,3-butadiene measured in urban air of the United Kindom have not exceeded 1 ppb as a running annual average. We therefore recommend 1 ppb, measured as a running annual average, as the Standard, and are of the view that, at this concentration, any risks to the health of the population are exceedingly small.

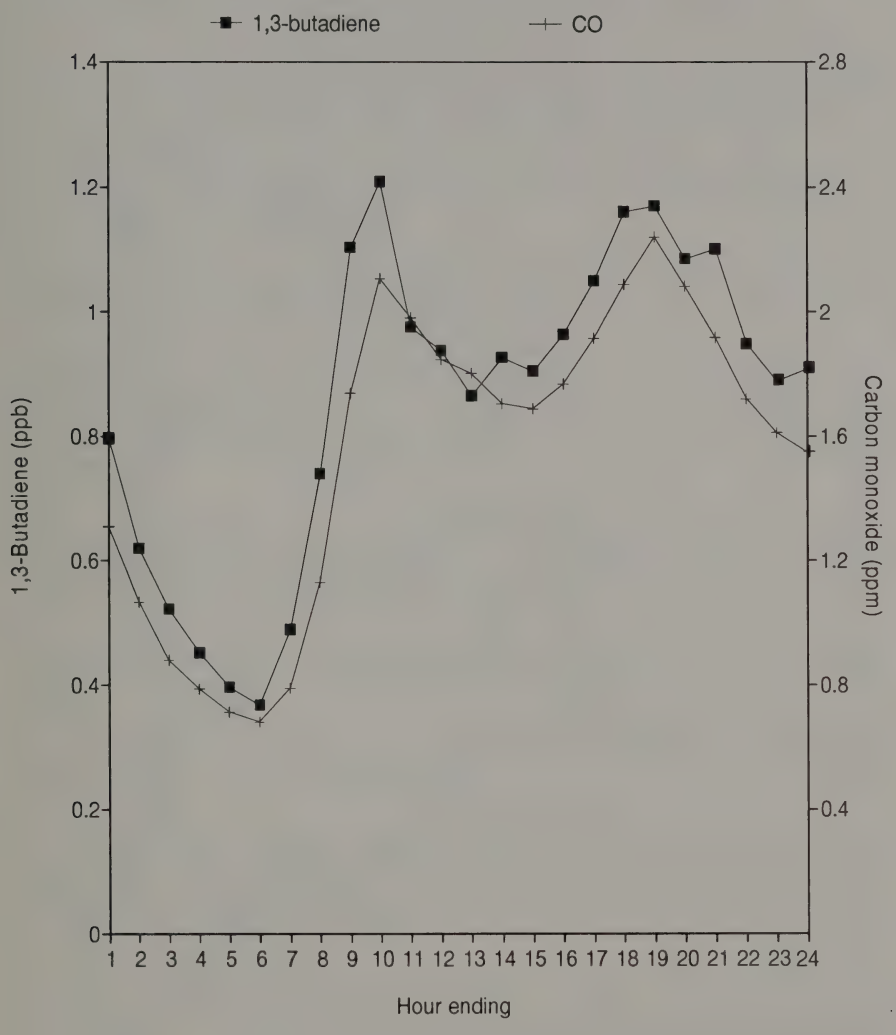
26. The Panel debated the principle, discussed in the Benzene report, that concentrations of genotoxic carcinogens should be subject to a Standard that is as low as practicable. In the case of benzene this had led to the recommendation of a target Standard. We have adopted a different approach for 1,3-butadiene for the following reasons: (a) by recommending a Standard at a value close to the current levels we have incorporated an additional ten fold safety margin below the figure derived from human epidemiology; (b) as we have noted, there are uncertainties inherent in the human data; (c) there are, as yet, only limited monitoring data; and (d) the data are insufficient to determine what effects recent pollution controls will have on the environmental levels of 1,3-butadiene. For these reasons we believe that the Standard, and the need for a target Standard, should be reviewed by the Panel within five years. In the interim, as a precautionary measure, we recommend that the Government's programme of air pollution controls should aim to ensure that, at any one site, the Standard is not exceeded and that there is an overall decline in measured 1,3-butadiene concentrations.

Recommendation for an Air Quality Standard for 1,3-Butadiene

27. **The Panel recommend an Air Quality Standard for 1,3-butadiene in the United Kingdom of 1 ppb measured as a running annual average. We also recommend that this Standard, and the need for a target Standard, be reviewed after a period of, at most, five years in the light of any additional human data and of the experience of improved pollution control. In the interim the Panel recommend that, as a precautionary measure, the Government's programme of air pollution controls should aim to ensure that, at any one site, the Standard is not exceeded and that there is an overall decline in concentrations.**

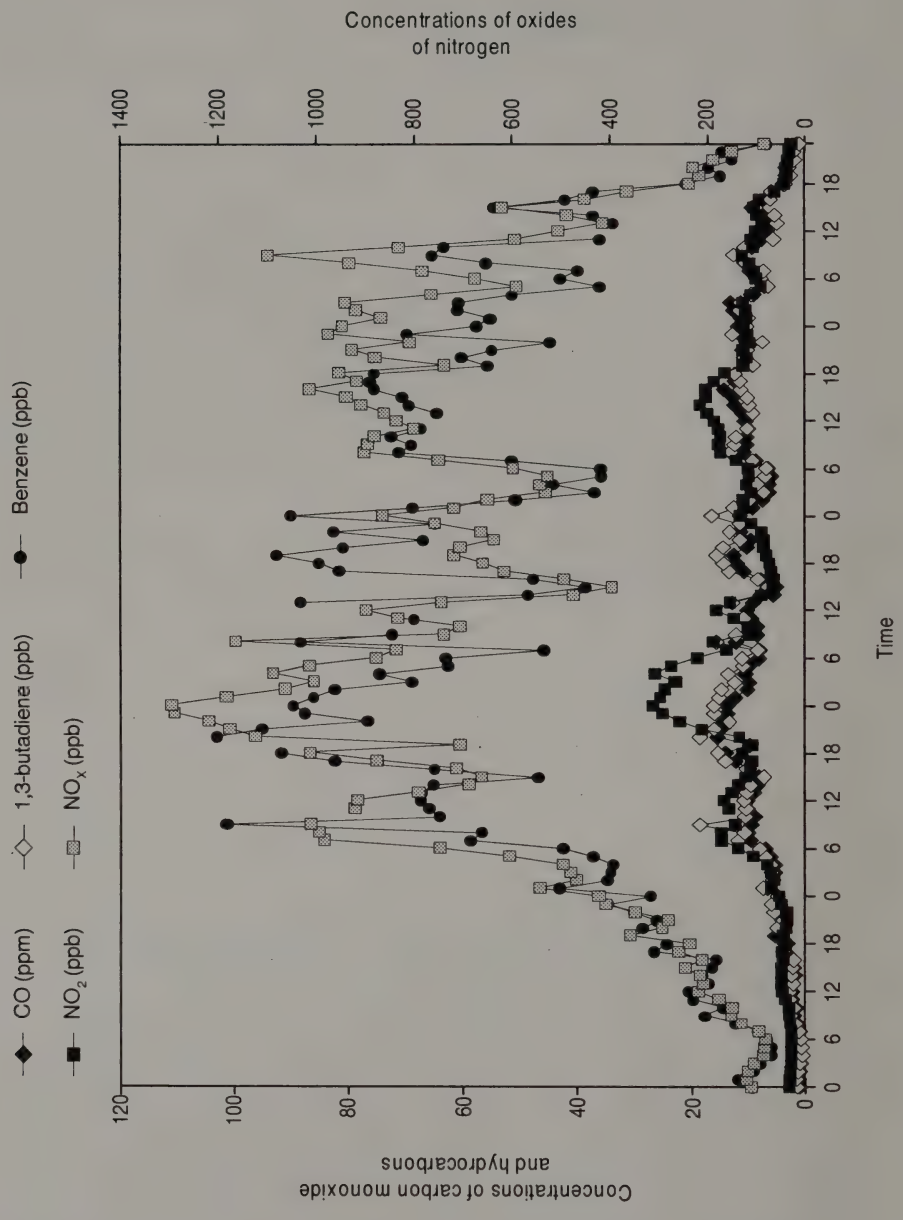
28. These recommendations are intended to reduce the cumulative lifetime exposure of the United Kingdom population to 1,3-butadiene. It is intended that the techniques for monitoring the Standard be consistent with those of the Department of the Environment's Enhanced Urban Network.

Figure 1 Average diurnal variation of 1,3-butadiene and carbon monoxide at the Exhibition Road, London roadside site – 19 July 1991 to 30 June 1992.



A3835 10/94 DDP Services

Figure 2 Concentrations of atmospheric contaminants at Exhibition Road, London – 11 December to 15 December 1991



BIBLIOGRAPHY

Acquavella JF, Cowles SR. Re: "Lymphohematopoietic cancer in styrene-butadiene polymerization workers". *Am J Epidemiol 1993*; 138:765-766.

Cowles SR, Tsai SP, Snyder PJ, Ross CE. Mortality, morbidity, and haematological results from a cohort of long term workers involved in 1,3-butadiene monomer production. *Occup Environ Med 1994*; 51:323-329.

Department of the Environment. Expert Panel on Air Quality Standards. *Benzene*. London. HMSO 1994.

Department of the Environment. *This Common Inheritance: Britain's Environmental Strategy*. Cmnd 1200, 1990. HMSO 1990.

Department of Health. Committee on Carcinogenicity of Chemicals in Food, Consumer Products and the Environment. *Guidelines for the Evaluation of Chemicals for Carcinogenicity. Report on Health and Social Subjects*, 42. London. HMSO 1991.

Department of Labor, Occupational Safety and Health Administration. 29 CFR Part 1910 Occupational exposure to 1,3-butadiene; proposed rule and notice of hearing. *Federal Register 1990*; 55(155):32736-32826.

Divine BJ. An update on mortality among workers at a 1,3-butadiene facility–preliminary results. *Environ Health Perspect 1990*; 86:119-128.

Downs TD, Crane MM, Kim KW. Mortality among workers at a butadiene facility. *Am J Ind Med 1987*; 12:311-329.

International Agency for Research on Cancer. 1,3-Butadiene *in* Occupational Exposure to Mists and Vapours from Strong Inorganic Acids; and other Industrial Chemicals, *IARC Monograph on the Evaluation of Carcinogenic Risk to Humans 1992*; 54:237-287.

Matanoski GM, Santos-Burgoa C, Schwartz L. Mortality of a cohort of workers in the styrene-butadiene polymer manufacturing industry (1943–1982). *Environ Health Perspect 1990*; 86:107-117.

Meinhardt TJ, Lemen RA, Crandall MS, Young RJ. Environmental epidemiologic investigation of the styrene-butadiene rubber industry. *Scand J Work Environ Health 1982*; 8:250-259.

Quality of Urban Air Review Group. First Report: *Urban Air Quality in the United Kingdom*. QUARG: London, 1993.

Quality of Urban Air Review Group. Second Report: *Diesel Vehicle Emissions and Urban Air Quality*. QUARG: London; 1994.

Santos-Burgoa C, Matanoski GM, Zeger S, Schwartz L. Lymphohematopoietic cancer in styrene-butadiene polymerization workers. *Am J Epidemiol 1992*; 136:843-854.

Santos-Burgoa C, Matanoski GM. Re: "Lymphohematopoietic cancer in styrene-butadiene polymerization workers". The authors reply. *Am J Epidemiol 1993*; 138:766-768.

World Health Organization. *Air Quality Guidelines for Europe*. WHO Regional Publications, European Series No 23 Copenhagen: World Health Organization, 1987.

Printed in the United Kingdom for HMSO
Dd. 300121 C28 10/94

Expert Panel on Air Quality Standards: 1, 3-Butadiene

HMSO

HMSO publications are available from:

HMSO Publications Centre
(Mail, fax and telephone orders only)
PO Box 276, London SW8 5DT
Telephone orders 0171 873 9090
General enquiries 0171 873 0011
(queuing system in operation for both numbers)
Fax orders 0171 873 8200

HMSO Bookshops
49 High Holborn, London WC1V 6HB
(counter service only)
0171 873 0011 Fax 0171 831 1326
68--69 Bull Street, Birmingham B4 6AD
0121 236 9696 Fax 0121 236 9699
33 Wine Street, Bristol BS1 2BQ
0117 9264306 Fax 0117 9294515
9–21 Princess Street, Manchester M60 8AS
0161 834 7201 Fax 0161 833 0634
16 Arthur Street, Belfast BT1 4GD
01232 238451 Fax 01232 235401
71 Lothian Road, Edinburgh EH3 9AZ
0131 228 4181 Fax 0131 229 2734

HMSO's Accredited Agents
(see Yellow Pages)

and through good booksellers

£5.95 net

ISBN 0-11-753034-4

9 780117 530348